

# UNEARTHING NEW JERSEY

NEW JERSEY GEOLOGICAL SURVEY  
Department of Environmental Protection

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## MESSAGE FROM THE STATE GEOLOGIST

The New Jersey Geological Survey provides geoscience information to government agencies, consultants, industry, environmental groups, and the public. This first issue of the Survey's newsletter, *Unearthing New Jersey*, highlights a sampling of current projects that use this information to address environmental concerns and make related economic decisions.

The Survey is particularly proud of the support it provided to the Governor's Task Force in preserving the New Jersey Highlands. An article by Jeff Hoffman highlights the importance of water resources in the Highlands to all citizens of New Jersey. Over one-third of the state's potable water is provided from the Highlands and almost two-thirds of the state's population depend on this water resource. This amounts to over 147 billion gallons of potable water used annually.

Geologic mapping has been the mainstay for the Survey since its inception in 1835. Scott Stanford writes about the uses of geologic maps to derive an earthquake hazard evaluation for Middlesex County. This derivative product provides earthquake damage predictions to the New Jersey State Police Office of Emergency Management Response and the Federal Emergency Management Agency for use in planning for emergencies. These evaluations have also been completed for five other urban counties of the state.

The New Jersey Geological Survey continues a focus on mineral resources with its efforts in mapping offshore deposits of sand and gravel. Jane Uptegrove reports on vibracoring and seismic surveys that are used to map the three dimensional distribution of these deposits on the sea floor. The Survey and DEP Engineering and Construction in cooperation with the US Army Corps of Engineers and the US Mineral Management Service assess this information to identify sand for replenishing and maintaining the beaches and dunes along the New Jersey coast. These features are the state's first line of protection against storm and wave damage.

The Survey welcomes feedback (<http://www.njgeology.org/comments.html>) you wish to provide on the content or format of this first newsletter. Other recent geologic activities and digital publications of the Survey are noted in the newsletter and elsewhere on the Survey's website. Printed maps and reports are available to the public through the DEP Maps and Publications Office (609-777-1038), PO Box 438, Trenton, N.J. 08625-0438 and a publications price list is maintained on web. Unpublished information is provided at cost by writing the State Geologist's Office, N.J. Geological Survey, PO Box 427, Trenton, N.J. 08625-0427. Staff are available to answer your questions 8:00 AM-5:00 PM Monday through Friday by calling 609-292-1185.

Karl W. Muessig,  
*New Jersey State Geologist*



Heaters Pond, Ogdensburg, Sussex County. Photo by R. Witte.

## PROTECTING THE HIGHLANDS' POTABLE WATER

*By Jeffrey L. Hoffman*

### INTRODUCTION

The Highlands Protection and Planning Act was initiated by the governor to focus attention on the water resources of the Highlands in northern New Jersey. The act highlights the importance of the area's water supply, and the steps needed to protect it. The headwaters of three major river systems -- the Passaic, Raritan and Wallkill -- are located in the Highlands which also contributes water to the Delaware River. Water for potable supplies is withdrawn directly in the Highlands and downstream from it. But how dependant is New Jersey on this water? Which municipalities depend on it and how dependant are they? The New Jersey Geological Survey (NJGS) determined that the Highlands supplied 34% of all the state's potable water used in 1999. It is estimated that Highlands water was distributed to 292 municipalities in 16 counties. Some municipalities were completely dependant on this water while others needed only a small amount. Taken together, a substantial 64% of the state's population receives some or all of its water from the Highlands.

### HIGHLANDS & SMART GROWTH

New Jersey's smart growth initiative encourages new development in designated 'growth areas' and strives to limit growth in environmentally sensitive locations. Under New Jersey's Development and Redevelopment Plan, the Highlands was declared a 'Special Resource Area' defined as: "an area or region with unique characteristics or resources

of statewide importance which are essential to the sustained well being and function of its own region and other regions or system--environmental, economic, and social--and to the quality of life for future generations."

This attention to the Highlands is not new. As far

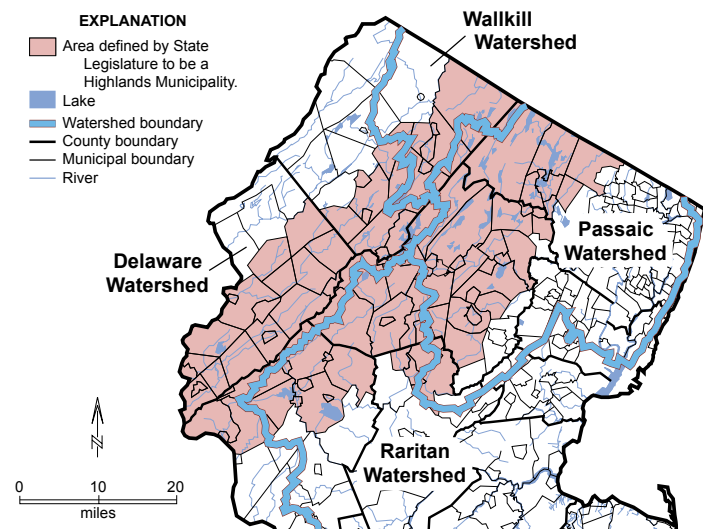


Figure 1. New Jersey Highlands Municipalities with major watersheds.

back as 1907 its significance to the water supply of New Jersey was recognized. In that year a report by the Potable Water Commission stated that "The Highland watersheds are the best in the state ... These watersheds should be preserved from pollution at all hazards, for upon them the most populous portions of the state must depend for water supplies. There has been too much laxness in the past regarding this important matter."

Recognizing its importance, Governor McGreevey said that "The Highlands is a critical resource that is experiencing tremendous pressure from population growth and development. Every effort must be made to aggressively preserve remaining open space and safeguard the region's precious water supplies."

## AREA DEFINITION

The State Development and Redevelopment Plan defines 90 municipalities in 7 counties (fig. 1) as 'Highlands Municipalities' (U.S. Forest Service, 2002). These municipalities cover 1,355 mi<sup>2</sup> or about 17% of New Jersey.



The headwaters of the Passaic, Raritan and Wallkill Rivers are located here (fig. 1) as is part of the Delaware River watershed. The Delaware and Passaic basins cover a little more than a third of the municipalities each: 484 mi<sup>2</sup> (36%) for the Delaware and 470 mi<sup>2</sup> (35%) for the Passaic watershed. The Raritan watershed covers 275 mi<sup>2</sup> (20%) of the Highlands municipalities. The remaining 126 mi<sup>2</sup> (9%) comprises the Wallkill watershed.

## WITHDRAWALS

The Highlands supplies potable water in two different ways. It is withdrawn from surface-water intakes and ground-water wells physically located in the Highlands, and it contributes to downstream surface-water supplies in the Raritan, Passaic and Delaware River through the runoff of precipitation.

Four hundred forty-four public potable-supply wells and surface-water intakes in the Highlands withdrew 76.9 billion gallons of surface water and 22.8 billion gallons of ground water in 1999. During that year private household wells withdrew approximately 7.6 billion gallons more, bringing the total amount withdrawn to approximately 107.3 billion gallons.

New Jersey also has 11 surface-water intakes for public potable supplies in the Delaware, Raritan, and Passaic watersheds downstream from the Highlands municipalities. In 1999 these withdrew 120.0 billion gallons of water (Hoffman and Domber, 2004), a portion of which came from the Highlands. Based on the relative volumes from each of the watersheds, about 40.5 of the 120.0 billion gallons

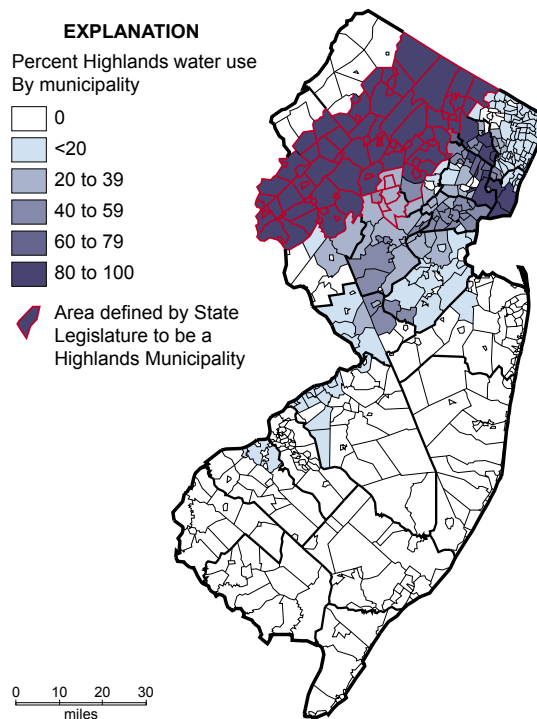


Figure 2. Percentage of potable-water supplied in 1999 to New Jersey municipalities from the New Jersey Highlands.

withdrawn came from the Highlands.

This means that an estimated 147.8 billion gallons of potable water came from the Highlands in 1999. Because

the total volume of potable water used by the state that year was 430.5 billion gallons, municipalities in the Highlands supplied an estimated 34% of all potable water used in New Jersey in 1999.

## TRANSFERS

It is important to note that in New Jersey water is not necessarily used where it is withdrawn. Water is routinely moved around the state using a complex series of reservoirs and pipelines that run between numerous sources and service areas. Some service areas may also have more than one water source. By carefully tracking water from its withdrawal point through various transfers and ultimately to the final area of use, the NJGS is able to estimate the percentage of water used in a municipality that came from the Highlands. This tracking technique was developed by NJGS as part of its work for the upcoming New Jersey state-wide supply plan. More information is available in Hoffman and Domber (2004) and Tessler (2003).

Boonton Reservoir in Morris County is a good example of how water is moved around in New Jersey. All of the water that fills the reservoir is runoff from the Highlands. A pipeline then carries it about 20 miles east to Jersey City in Hudson County, making it the city's single source of water. Other municipalities get small amounts of water from the Highlands. It is estimated that a major intake on the Delaware River in the Camden area receives just 7 percent of its water from the Highlands (Hoffman and Domber, 2004). This water is then distributed to a number of municipalities in southwest New Jersey where it is further blended with additional sources.

Figure 2 shows municipalities that received all or part of their potable water from the Highlands in 1999. Again, note that some of the 292 municipalities and 16 counties receive every drop of potable water from the Highlands, while others use only a small amount. In total, these municipalities contain about 64% of the state's population. If water from the Highlands were to be eliminated, all of these people would be affected.

All references in the text, and a list of Internet resources, can be found in Hoffman, J. L. and Domber, S. E., 2004, Potable water supplied in 1999 by New Jersey's Highlands: technical staff report, N.J. Geological Survey, 8p, available on the Internet at <http://www.savethehighlands.org/>.



## PREDICTING EARTHQUAKE DAMAGE IN MIDDLESEX COUNTY

By Scott D. Stanford

They may be rare, but damaging earthquakes have occurred in New Jersey's past and undoubtedly will in its future. In 1737 an earthquake with an estimated magnitude of 5.0 on the Richter scale occurred in the vicinity of New York City, and another of magnitude 5.5 jolted the area in 1884. Historically, stronger earthquakes (magnitudes 6

and 7) were recorded near Charleston, South Carolina and Boston, Massachusetts. Because New Jersey is in a similar tectonic setting, earthquakes of these magnitudes can also occur in this state.

To predict the potential effects of earthquakes, the New Jersey Geological Survey is using computer software developed under the direction of the Federal Emergency Management Agency (FEMA). Following data entry that simulates geological and other conditions by census tract (small statistical subdivisions of a county designated by the U.S. Census Bureau), the software calculates damage to buildings, utilities, highways, bridges, and other facilities. Crucial geologic data includes a soil class map that calculates the intensity of ground shaking, a liquefaction susceptibility

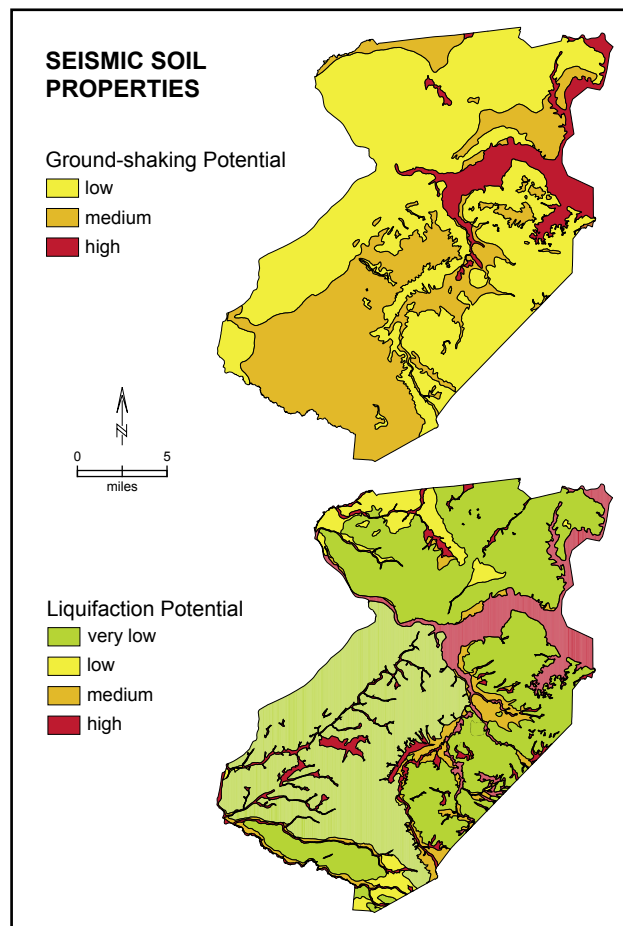


Figure 1. Seismic soil properties in Middlesex county.

map that identifies areas where soils may flow as liquids when shaken, and a landslide potential map to identify area where slope failure might occur.

Soil class is determined by the compaction and density of unconsolidated deposits and bedrock to a depth of 100 feet below land surface. Compact sediments and hard rock transmit seismic energy more efficiently than loose sediments, resulting in less ground shaking. Liquefaction susceptibility is highest in deposits that contain saturated, loose sand and silty sand. These soils can act as a liquid, losing strength when shaken by earthquakes. Landslides can also be triggered during an earthquake. The greatest potential for this is where slopes of wet clay are steep (>20

degrees). Dry sandy soils or rock with slopes less than 10-15 degrees have little landslide potential.

In Middlesex County the materials most susceptible to shaking and liquefaction are loose deposits in floodplains, wetlands, estuaries, and salt marshes (fig. 1). Somewhat less susceptible are deposits of former rivers, and thick deposits of glacial-lake sediment and till (fig. 1). Areas of thin glacial and river deposits, outcropping bedrock, and outcropping Coastal Plain formations, have a low shaking potential and a low to very low liquefaction potential (fig. 1). Only a small area of the County has slopes with landslide potential.

To determine the proper soil class, compaction is measured in two ways. The first method, known as a Standard Penetration Test, is routinely performed during preparation for construction projects. A standard 140 pound weight falling freely 30 inches, drives a sampling tube into the

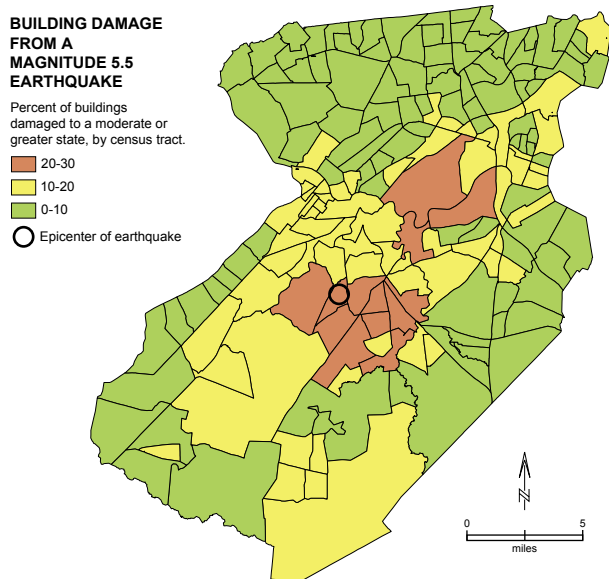


Figure 2. Building damage from a magnitude 5.5 earthquake.

sediment with repeated blows. The number of blows needed to drive the tube one foot into the soil is counted, recorded, and later used for analysis. Approximately 3500 penetration tests from 450 borings were collected in Middlesex County and used to determine soil class.

A second method used to help determine soil class is to measure the velocity of shear waves in the soil using geophysical survey equipment. Shear waves are mechanical vibrations that cause side-by-side motion of particles as they travel through a material. Twelve such measurements were made in Middlesex County, three each on four soil types.

Using standard penetration tests and shear-wave measurements, glacial till has been shown to be a compact sediment because it was subjected to the enormous weight of continental ice sheets. Sand and clay of Coastal Plain formations is also compact, but these were compressed by several hundred feet of overlying sediments that have since been eroded away. River, wetland, and estuarine deposits, which were never covered by a glacier or by thick overlying sediments, are much less compact.

Potential damage to buildings constructed on these soils

is shown on figure 2. Census tracts close to the simulated epicenter that have large areas of soils with high or medium ground-shaking and liquefaction potential suffer the greatest building damage (fig. 2). In these tracts it is estimated that 20 to 30 percent of buildings would be damaged to a moderate or greater extent. Moderate damage requires evacuation and assessment before reoccupancy, and represents a significant social disruption. Census tracts farther from the epicenter but still with sizable areas of soil with medium or high ground-shaking and liquefaction hazard show 10 to 20 percent damage (fig. 2). Tracts with low soil hazard, and those farthest from the epicenter, show the least damage (fig. 2). For the entire county, a simulated magnitude 5.5 earthquake at the epicenter shown on figure 2, would cause major damage to 1000 to 6000 buildings and displace between 1200 and 5000 households. The simulation software also calculates estimates of financial loss. For the magnitude 5.5 earthquake shown in figure 2, the total economic loss for the county, which includes building damage, loss of building contents and loss due to business interruption, is estimated at between 1.3 and 5.2 billion dollars.

The New Jersey Geological Survey has completed similar earthquake damage assessments for Essex, Bergen, Hudson, Union, and Passaic Counties (<http://www.njgeology.org/enviroed/infocirc/eqdamage.pdf>). The geologic data acquired from these assessments can be used to identify areas with vulnerable soil and then prioritize efforts to strengthen critical structures. Additional counties in northeastern New Jersey will be completed in the future. Funding for this work is provided by the New Jersey State Police, Office of Emergency Management.



## OFFSHORE SAND EXPLORATION FOR SHORE PROTECTION PROJECTS

by Jane Uptegrove

New Jersey's active and successful shore protection program requires large and readily available sources of offshore sand for beach nourishment projects. Through cooperation of the New Jersey Geological Survey (NJGS) and other state and federal agencies, potential sources of sand are located for these projects. The work helps to ensure long range plans that protect the safety and property of New Jersey's citizens.

NJGS collects vibracores each year as part of an ongoing offshore resources exploration project. To date, an excess of 125 vibracores have been drilled along the length of the New Jersey Coast. In June 2004, the New Jersey Geological Survey Offshore Resources Exploration Team drilled twenty vibracores in and around potential offshore sand resources, each to a depth of 20 feet (fig. 1). The coring investigated a stretch from Brigantine to an area south of Corson's Inlet.

This year sites were selected based on review of approximately 300 line-miles of a seismic survey done in 2003. Target areas were identified in consultation with

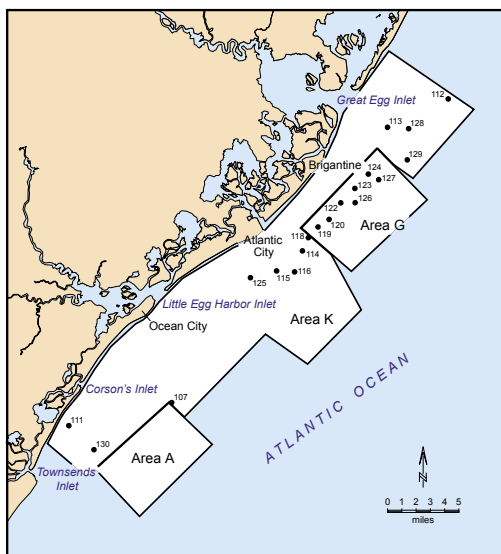


Figure 1. Viracore location map.

the U.S. Army Corps of Engineers and included shoal features offshore of Atlantic City, Brigantine, Ocean City and Longport. Drilling was extended north and east of Brigantine to improve coverage of shoal and channel features in the vicinity of Little Egg Inlet. As illustrated on the map (fig. 1), the majority of drilling locations run parallel to the coast approximately 3 miles offshore. Shoals nearer to shore were

sediments. As the barrel is driven into the sediments, a sensor called a penetrometer that is mounted on the core bit records the time elapsed and depth of penetration. The power of the pneumatic hammer determines how deep the core barrel will penetrate. Typically, a 20-foot core is drilled in about three minutes. If any 1-foot interval takes more than one minute the drilling is stopped. The sample is then brought to the work deck, extracted, and a second run re-started where the first drilling left off. Resistance is encountered at gravel- or clay-rich zones, and the graph created by the penetrometer is correlated with the seismic profile and the lithologic log from the core. Twenty-foot cores are economically collected in this shallow setting, and provide quality samples to the depth of penetration. Checked against the seismic profile, sediment intervals disturbed during the drilling process can be corrected. Thus, while vibracore drilling is limited to shallow cores, it does provide sediment samples and verifiable lithologic contacts that enable stratigraphic correlation.

## EXTRACTION AND ANALYSIS

When a core is brought to the deck of the ship, the clear PVC tubing containing the sample is extracted from the core barrel. At this time NJGS performs a preliminary lithologic description and the core is sectioned for storage and transport. This first, brief examination can reveal the depth of lithologic contacts, organic material for dating, and grain size characteristics. At the Survey's facility in Trenton, the cores are split lengthwise, photographed, described, and sampled every 30 cms for grain size analysis (fig. 3).

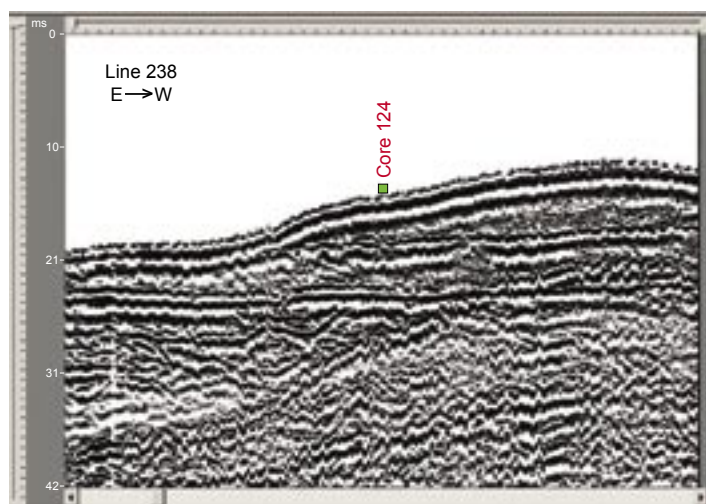


Figure 2. Seismic line with core location.

not sampled because the Survey does not have seismic 2-D data for them, nor would potential deposits close to shore be candidates for dredging because of their importance in modulating near shore and onshore wave energy.

## WHY A 20-FOOT CORE?

As discussed in the NJGS Information Circular "Sand Resources for Shore Protection Projects in New Jersey" (<http://njgeology.org/enviroed/infocirc/sand.pdf>), analysis of 2-D seismic data alone show only the shape and location of sediment layers (fig. 2). Physical samples are required to determine the material's composition. These are retrieved from a ship using a pneumatic hammer that drives a steel barrel with a tube of clear PVC lining 20 feet into sea floor

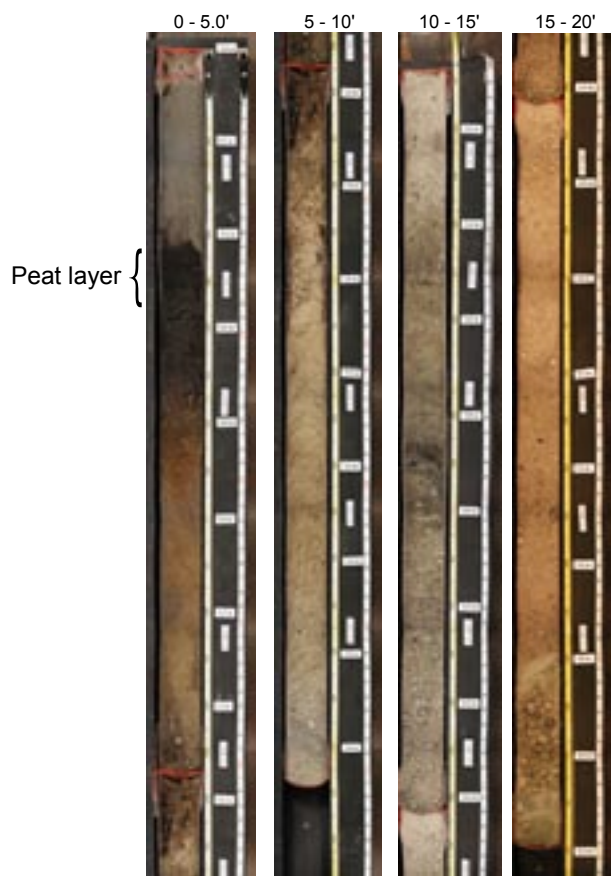


Figure 3. Core 127. Peat layer was sent for radiocarbon dating.

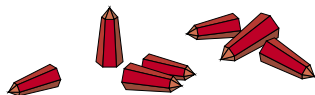
Organic material is also sampled at this time and sent to a lab for radiocarbon age-dating or amino-acid racemization. To illustrate, figure 3 shows Core 127 which penetrated a peat layer thought to have been deposited in a back barrier lagoon as sea level rose after the last glacial maximum, approximately 20,000 years ago. The lagoon was at sea level at the time of deposition. A radiocarbon date of the peat would determine when the sample was at sea level, and by extension, when it was deposited along the Atlantic coast.

## A GEOLOGIC FRAMEWORK

Seismic surveys, and vibracore sampling are essential to develop a geologic picture that will provide a framework to evaluate individual shoal features found on the shelf. Correlation of lithologic units between vibracores and along or between seismic profiles enables Survey geologists to create computer images and calculate sand volumes. This

**Title background:** A photo collage of the mineral zincite [ZnO]. Zincite, from mines at Franklin and Ogdensburg, New Jersey, was described and analyzed by Dr. Archibald Bruce in 1810. This was one of the earliest mineralogical investigations in this country. Bruce called the mineral "red oxide of zinc", Wilhelm K. von Haidenger gave it the name "zincite" in 1845. Color ranges from deep red ("ruby zinc") to orange-yellow. Zincite is an uncommon mineral and well-developed crystals (euhedral) are exceedingly rare.

Photos by J. H. Dooley.



## NEW PUBLICATIONS

### NJGS OPEN-FILE MAP SERIES (OFM)

**NEW MAP.** Ground-Water Recharge and Aquifer Recharge Potential for Monmouth County, New Jersey, French, Mark A., 2003, scale: 1 to 100,000, size 36x55. OFM 53. \$15.00

**NEW MAP.** Surficial Geology of the Woodbury Quadrangle, Gloucester County, New Jersey, Stanford, Scott D., 2004, scale: 1 to 24,000, size 32x36, 1 cross-section. OFM 58. \$10.00

**NEW MAP.** Bedrock Geology of the Woodbury Quadrangle, Gloucester County, New Jersey, Stanford, Scott D. and Sugarman, Peter J., 2004, scale: 1 to 24,000, size 31x32, 1 cross-section. OFM 59. \$10.00

**NEW MAP.** Surficial Geology of the Camden and Philadelphia Quadrangles, Camden, Gloucester and Burlington Counties, New Jersey, Stanford, Scott D., 2004, scale: 1 to 24,000, size 32x39, 2 cross-sections. OFM 60. \$10.00

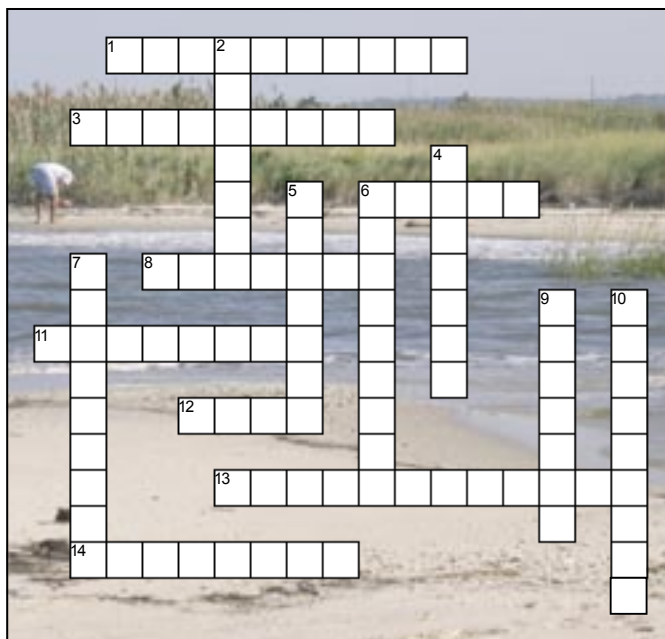
**NEW MAP.** Bedrock Geology of the Camden and Philadelphia Quadrangles, Camden, Gloucester and Burlington Counties, New Jersey, Stanford, Scott D., Sugarman, Peter J. and Owens, James P., 2004, scale: 1 to 24,000, size 33x36, 2 cross-sections. OFM 61. \$10.00

### NJGS TECHNICAL MEMORANDA (TM)

**NEW REPORT.** Modifications to New Jersey's Watershed Management Area Boundaries, 1996-1999, Hoffman, Jeffrey L., 7 p., 5 illus., 4 tables. TM 04-01. \$2.00

information is used to replenish eroded beaches identified by the U.S. Department of Interior's Minerals Management Service, the US Army Corps of Engineers, and the New Jersey Department of Environmental Protection.

This method has proved to be a cost-effective approach to locating and characterizing sand resources for shore protection. Cooperation between NJGS and our client agencies allows for the sharing of expertise and funding, and supports regional, long-term planning to protect New Jersey's people, property, coastal wildlife habitat, and the beauty of the scenic coastline.



## GEOLOGY CROSSWORD TIDES

### ACROSS

1. The source of a stream; its younger part.
3. The study and description of rocks.
6. A shallow submerged ridge, bank or bar of sand.
8. A salt of nitric acid.
11. The action of reducing concentration.
12. A compact, mixed sediment deposited by a glacier.
13. A condition where sands and silts flow as liquids when shaken.
14. The process that adds water to a saturated zone or aquifer.

### DOWN

2. A persistent period of less than normal precipitation.
4. Water fit to drink.
5. The deeper part of a moving body of water, where the main current flows.
6. A ground motion where particles move side-to-side.
7. The point on the earth's surface directly above the location of an earthquake.
9. Pertaining to earthquake or Earth vibration.
10. A branch of geology that studies large-scale structures of Earth's crust.

**ANSWERS.** Across: (1) headwaters, (3) lithology, (6) shoal, (8) nitrate, (11) illuvial, (12) till, (13) liquefaction, (14) recharge. Down: (2) drought, (4) potable, (5) channel, (6) shearwave, (7) epicenter, (9) seismic, (10) tectonics.